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Information Technology Laboratory

Coffeeville Lock and Dam Earthquake Event Report for the Alabama 22 March 2005 M_w = 3.3 Earthquake

By Don Yule, Tina Grau, Bruce Barker, and Ricky Floyd

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ERDC
Engineer Research and Development Center

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Purpose

This report documents the earthquake strong-motion accelerograms recorded during the 22 March 2005 08:11:50 (UTC) Alabama earthquake. Accelerograms were collected from the USACE Mobile Engineer District's Coffeeville Lock and Dam by the USACE Strong-Motion Instrumentation Program (SMIP) service technician (directed by Engineer Research and Development Center's (ERDC) Information Technology Laboratory (ITL) Data Acquisition and Integration Branch)) and analyzed by the SMIP Program Manager (Geotechnical and Structures Laboratory). The USACE SMIP is executed by the USACE ERDC (USACE, 1981; Ballard, 1998) and is responsible for analysis and interpretation of earthquake data (USACE 1979).

Earthquake Event Information

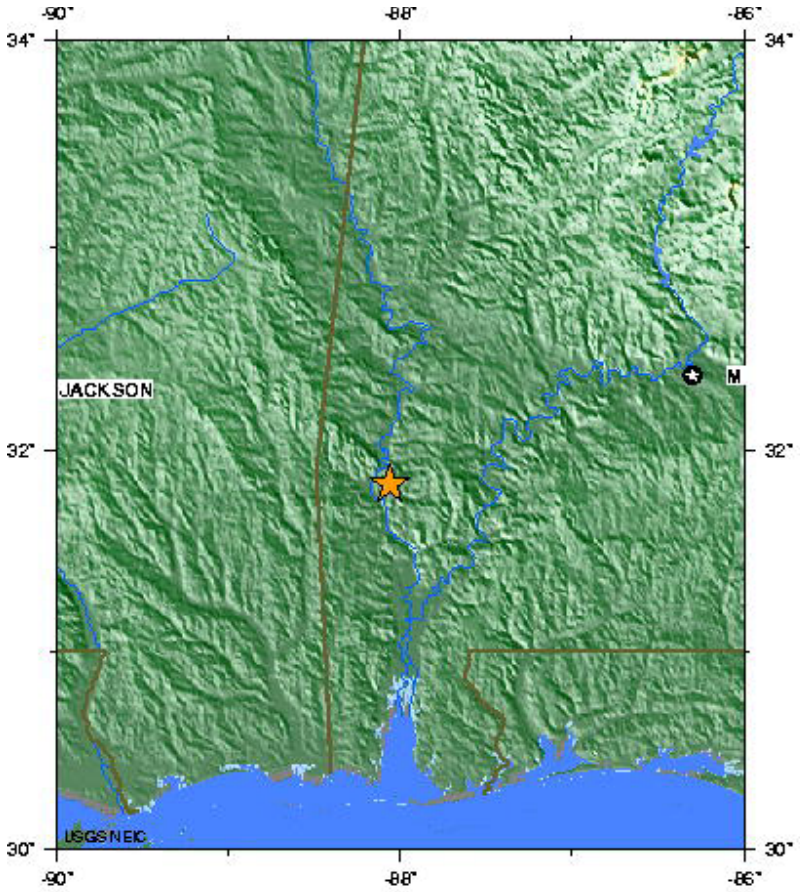
This earthquake was reported by the United States Geological Survey (USGS) National Earthquake Information Center (NEIC) web page release (Figure 1):

The following is extracted from this web-based earthquake report:

Magnitude 3.3 ALABAMA
Tuesday, March 22, 2005 at 08:11:50 UTC

Preliminary Earthquake Report
U.S. Geological Survey, National Earthquake Information Center
World Data Center for Seismology, Denver

Magnitude	3.3
Date-Time	**Tuesday, March 22, 2005 at 08:11:50 (UTC)** - Coordinated Universal Time Tuesday, March 22, 2005 at 02:11:50 AM local time at epicenter Time of Earthquake in other Time Zones
Location	31.83N 88.06W
Depth	5 kilometers
Region	**ALABAMA**
Reference	40 km (25 miles) NNW of **Jackson, Alabama** 60 km (35 miles) SSW of **Linden, Alabama** 175 km (110 miles) WSW of **MONTGOMERY, Alabama** 285 km (175 miles) NE of **New Orleans, Louisiana**
Location Quality	Error estimate: horizontal +/- 17.0 km; depth fixed by location program
Location Quality Parameters	Nst=9, Nph=9, Dmin=165.6 km, Rmss=0.16 sec, Erho=17.0 km, Erzz=0 km, Gp=204.2 degrees
Source	USGS NEIC (WDCS-D)
Remarks	Felt (IV) at Coffeeville and (II) at Jackson.



ALABAMA
2005 03 22 08:11 UTC 31.83N 88.06W Depth: 5km, Magnitude: 3.3
U.S. Department of the Interior, U.S. Geological Survey
URL: http://neic.usgs.gov/neis/bulletin/neic_teak.html

Figure 1. USGS NEIC web-based earthquake report

This earthquake is plotted on a seismicity map for 1977 to 1997 prepared by the USGS NEIC showing the earthquake in context to the region's seismicity (Figure 2). As can be seen, this earthquake's location is not unexpected. The largest reported earthquake for this region is the Irondale, Jefferson County, Alabama 1916 event, near Birmingham with an magnitude estimated from felt area of M_{fa} = 5.1. The most recent significant earthquake in the area was the 1997 Oct 24 08:35 4.9M Intensity VI Near Brewton, Alabama (31.118N 87.3390W). This 1997 earthquake was 103 km southeast and 58 km south from Coffeeville and Claiborne Lock and Dams, respectively.

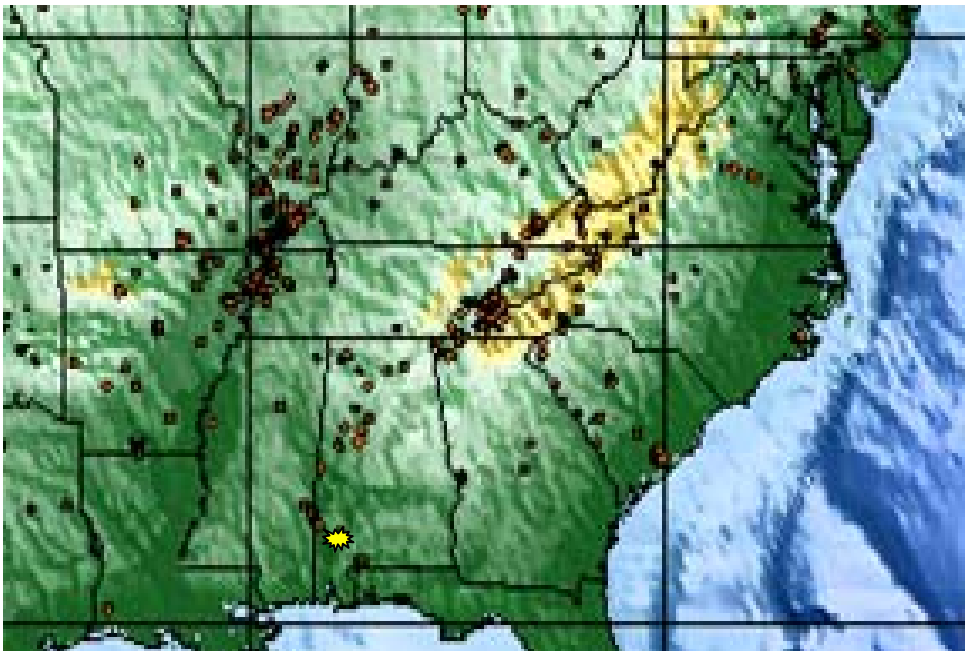


Figure 2 Seismicity (red) and Alabama 22 March 2005 M_w = 3.3 event (gold star)

Figure 2 presents the epicentral location of the 22 March earthquake and USACE dams within a 200 km radius. Also plotted on this map is the USGS catalog of earthquake locations up to 1996. The two closest dams coincidentally were instrumented with earthquake strong motion accelerographs. These dams and their distances to the earthquake epicenter are annotated. Only the accelerograph at Coffeeville Lock and Dam was triggered at an epicentral distance of 7.7 km.

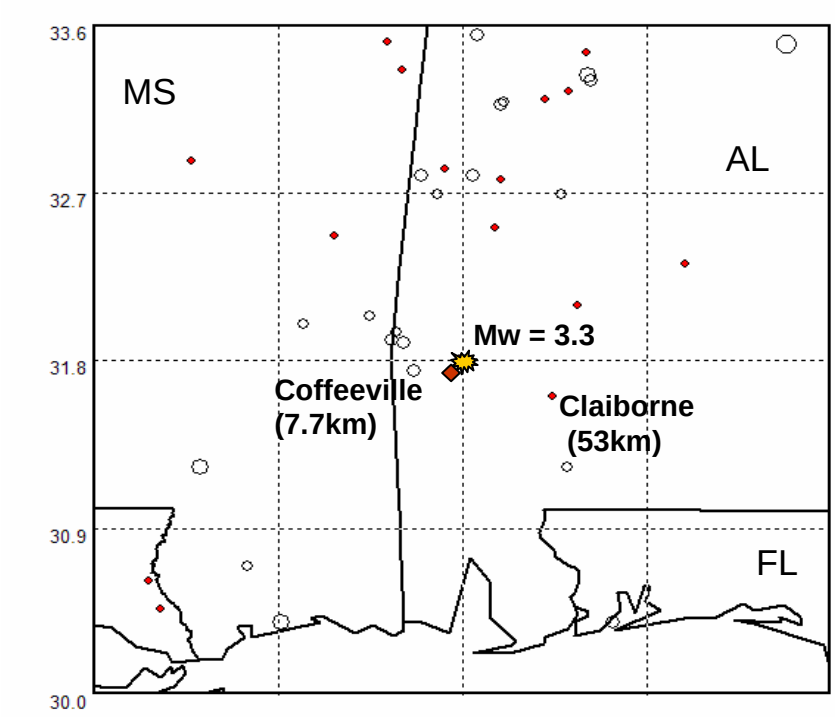


Figure 3. Earthquake location and USACE projects within 200 km. (Annotations: Red - USACE projects; black - earthquake locations; gold - 22 Mar 05 earthquake.)

Strong-Motion Accelerograph Location

The accelerograph at Coffeeville is located on the first floor of the Lock Control House. This strong motion accelerograph is a Kinemetrics model ETNA. The ETNA's sensor is a Triaxial EpiSensor force balance accelerometer, orthogonally oriented (two horizontal and one vertical

channels), with a full-scale range of 2g and a bandwidth of DC to 200 Hz. The overall system response is DC to 80 Hz for the sampling rate of 200 samples per second with 18 bits of resolution with 108 dB dynamic range. The location of this instrument in plan view is shown in Figure 4, and photographs of the lock control house where it is located are shown in Figure 5. The Y-L component of the instrument was aligned parallel with the axis of the lock and dam.

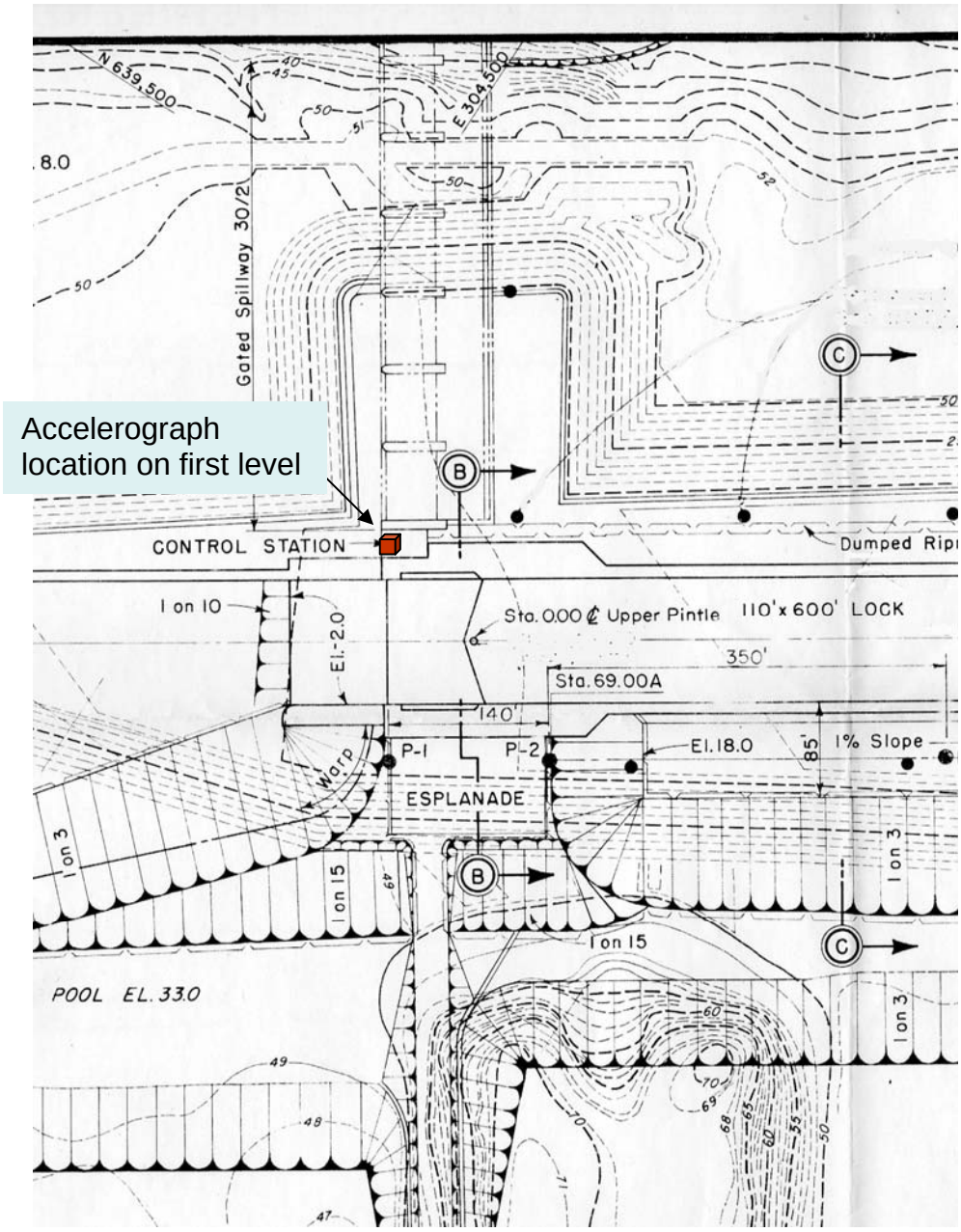


Figure 4. Photograph and plan view showing location of strong-motion instrumentation at Coffeeville Lock and Dam, AL.

Accelerograph location on first level in lock control

Figure 5. Photographs of station at Coffeeville Lock and Dam.

Data Analysis

This earthquake triggered the accelerograph only at Coffeeville Lock and Dam (Table 1). The next nearest accelerograph at Claiborne Dam was operational but did not trigger — being too distant from earthquake to experience ground motions that would exceed the trigger threshold of 0.08 g's.

Table 1. Nearest USACE SMIP Sites During 22 March 2005 Earthquake

Station	State	Type	H (m)	Recorder Type	S/N	Location	Coordinates	Triggered
Coffeeville Lock & Dam	AL	Concrete	27	ETNA	3392	1st Level, Lock Control House	-88.128/31.756	Yes
Peak (g)								**Trigger Level**
x-T_	0.015							0.008
y-L_	-0.023							0.008
z-Up	-0.013							0.008
Claiborne Lock & Dam	AL	Concrete	27	ETNA	2136	2nd Level, Lock Control House	-87.550/31.615	No

Data analysis processing of recorded data was needed to remove instrument response and convert data to engineering units. Data are presented for each channel as time history plots of acceleration and acceleration response spectra. These data are presented in Figures 6 and 8 for Coffeeville Lock and Dam.

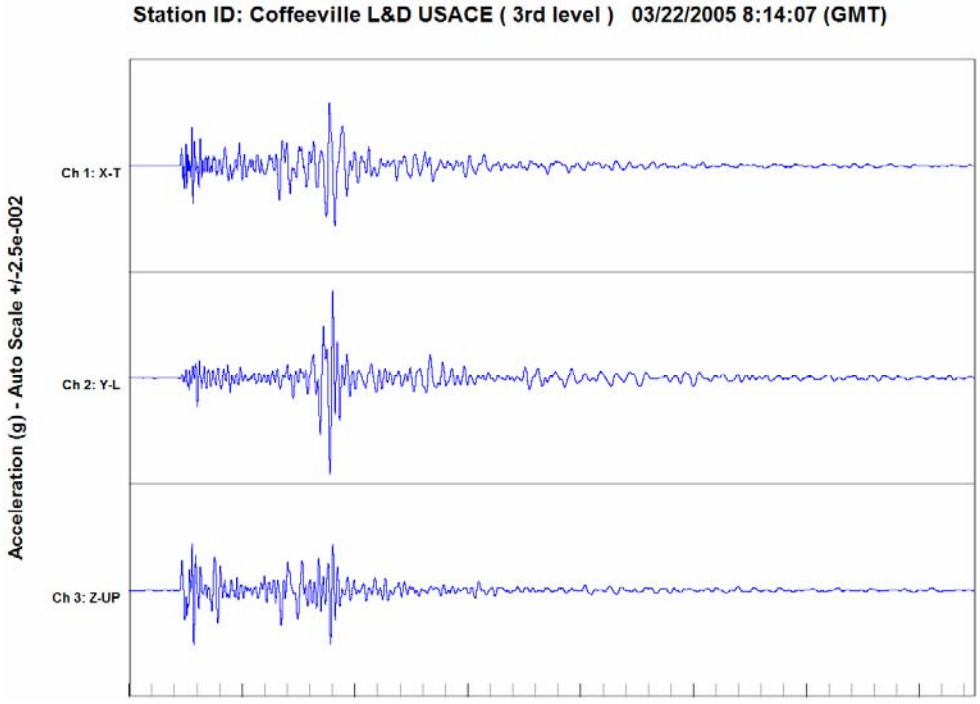


Figure 6. 22 March 2005 Mw=3.3 earthquake acceleration time history plots recorded at Coffeeville Lock and Dam.

Strong-motion monitoring is important to provide post earthquake data for determining earthquake loading to the structure, thus providing a rational basis for any post earthquake inspections or actions and input into future design and analysis of the project. One aspect is to assess whether this event was unexpected, having unusually larger ground motions than considered in the design, or was from a source not considered in determining the project's seismic hazard. As discussed previously, current knowledge of regional seismicity sufficiently accounts for this event. This earthquake size is also significant but smaller than the largest historical event for this region. Another consideration is regional attenuation relationships that are used to determine the level of shaking for a given distance from a given size source earthquake. One attenuation relationship applicable to this region is plotted in Figure 7 to enable a comparison between what is expected (mean value) and what was recorded. The attenuation relationship selected, Toro et al and Silva, 1997, is the most recent based on shallow crustal earthquakes in the central eastern United States (CEUS). This selected attenuation relationship and others are reviewed and documented in the Seismological Research Letters Journal of the Seismological Society of America (Toro et al, 1997). However, this event was a Magnitude M_w = 3.3 and the attenuation relationship shown is only applicable down to M_w =5.0 level. Therefore, this only provides a comparison to a much larger event, the 1997 M=5.1 event discussed earlier which is a reasonable but rare event for this area and an event that this project should expect to experience. Also, the plotted relationship is for a rock site and for conditions where local site effects do not dominate. Since these data were recorded within a structure, we can expect that the resulting ground motions may be modified by the dynamic response of this building. This may have caused amplification at the fundamental period of the structure. Taking these factors into consideration, we can conclude that the ground motions are not significantly greater than we would expect for this size event at this distance.

The next factor to investigate is what level of design is comparable to this earthquake. USACE Engineering Regulation, ER 1110-2-1806, (USACE, 1995) prescribes the development and selection of design earthquake ground motions for two levels of design: a maximum design event (MDE) and an operating basis design earthquakes (OBE). The MDE level uses the Maximum Credible Earthquake (MCE) arrived by the deterministic method for evaluating critical features of a structure. For non-critical elements, an MDE, which is less than the MCE, is used for an MDE and can be developed using deterministic and/or probabilistic procedures. The MDE has ground motion levels for a nominal 1000-yr exposure period for non-critical structures in CEUS. An OBE is used for design against economic losses, which specifies an earthquake generated ground motion with a 50% probability of exceedance in the service life of the structure. In this case for a service life of 100 years, the return period is 144 years. Figure 7 presents the 1000 yr MDE and OBE level earthquakes for the Coffeeville Lock and Dam, which was closest to this earthquake's source. These data were obtained from the probabilistic hazard characterization data developed for the National Seismic Hazard Mapping Project completed in 2003 by the USGS for the National Earthquake Hazard Reduction Program (Frankel et al, 1996, 2002).

Analysis of the recorded strong-motion data shows that this event is greater than the OBE design level. This exceeds the design level from which we can expect no consequential damage to the project features. However, since this was recorded within the structure it may have been amplified by the dynamic response of the building. Even though the earthquake was located near the project and generated moderate ground motions, being a small magnitude earthquake the predominant energy was in the high frequency range and with a very short duration of shaking (~2 seconds). This short duration, high frequency ground motion would not usually cause structural damage but could damage shock sensitive electrical and mechanical equipment. No damage was reported at the project due to this earthquake.

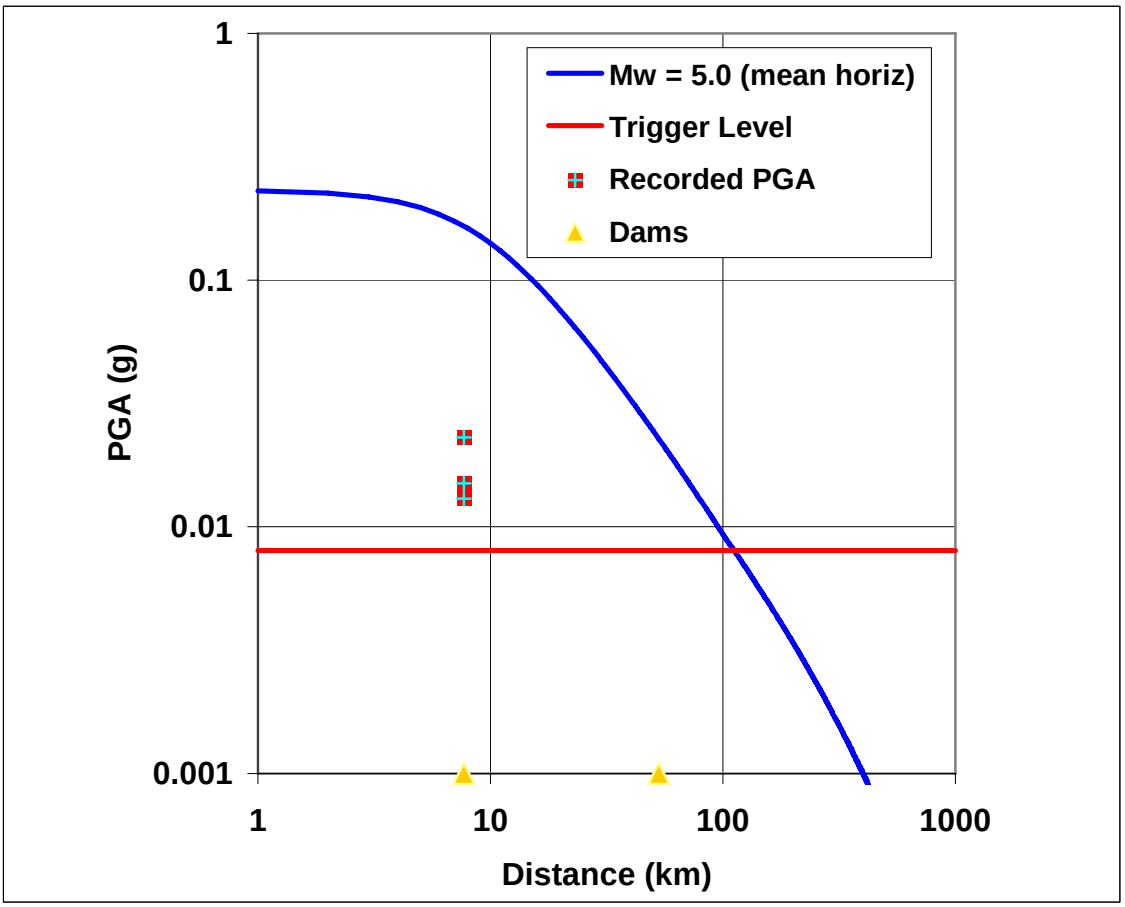


Figure 7. Comparison of PGA for recorded M_w = 3.3 and a M_w = 5 earthquake.

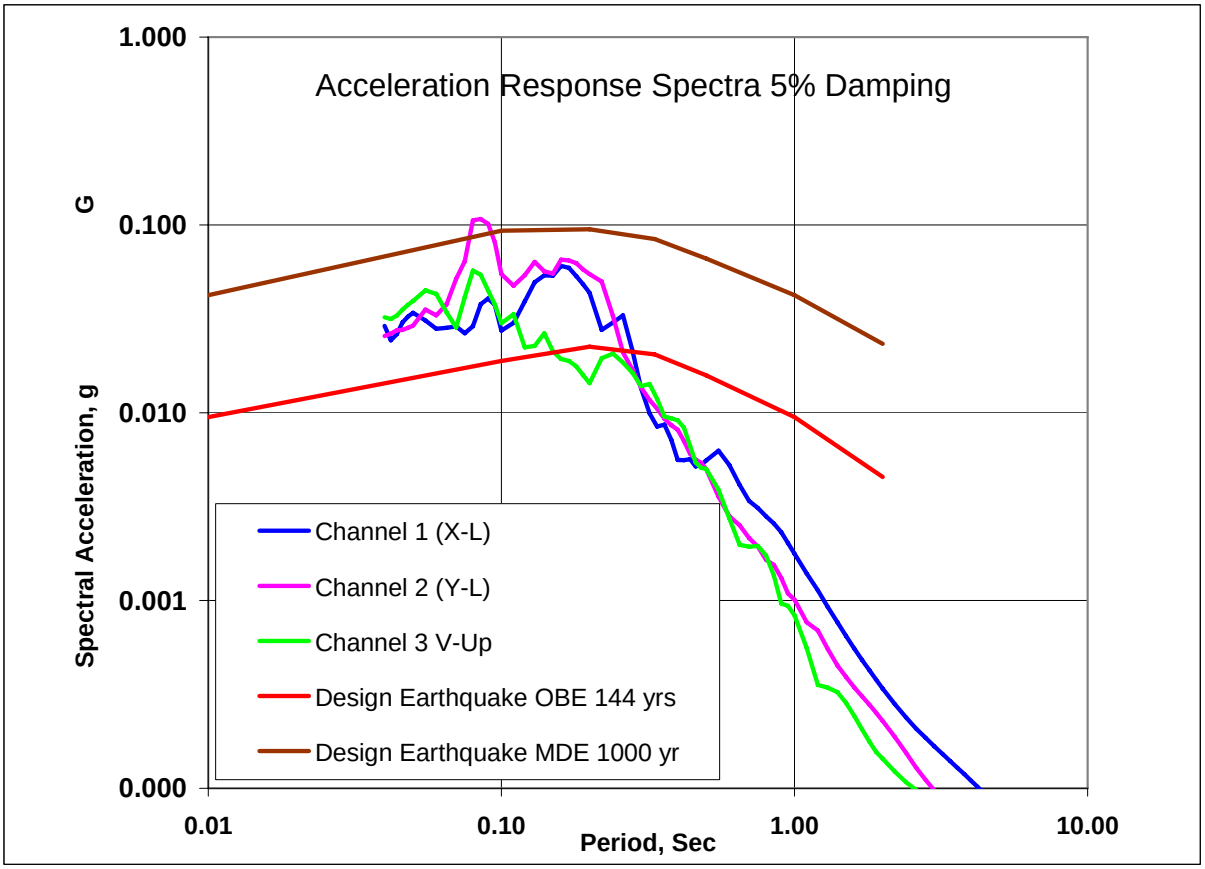


Figure 8. Comparison of recorded ground motions and design earthquake levels.

Conclusion

As a result of the 22 March 2005 08:11:50 M_w=3.3 earthquake 40 km (25 miles) NNW of Jackson, Alabama, one accelerograph was triggered on the 1st level of Coffeeville Lock and Dam, at a distance of 7.7 km. Although this earthquake was a significant regional event, its location and size are not unexpected. Analysis of the recorded strong-motion data shows that this event is greater than the OBE design level which defines the maximum event from which we can expect no consequential damage to the project features. However, since this was recorded within the structure, it may have been amplified by the dynamic response of the building. Also since the earthquake was located near the project, it generated high amplitude ground motions; but being a small magnitude earthquake, the predominant energy was in the high-frequency range with a very short duration of shaking (approximately 2 seconds). This short duration, high-frequency ground motion would not usually cause structural damage but could damage shock sensitive electrical and mechanical equipment. No damage was reported at the project due to this earthquake. These strong-motion data are available from the USACE SMIP Program Management office and will be provided to the USGS National Strong Motion Program for archiving.

References

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USACE SMIP Points of Contact:

Program Manager:	Don Yule	Don.E.Yule@erdc.usace.army.mil	601-634-2964
Program Administration:	Tina Grau	Tina.H.Grau@erdc.usace.army.mil	601-634-2372
Instrumentation Service:	Bruce Barker	Bruce.C.Barker@erdc.usace.army.mil	601-634-2536
Field Service:	Ricky Floyd	Richard.H.Floyd@erdc.usace.army.mil	601-634-2578

Event File Header

```
QLWIN: C:\SMIP\EARTHQ~1\ALEQ03~1\CF003.EVT   03/22/2005 09:14
Altus Header, Version. 1.30,  S/N 3392
 Etna  Stn: ERDC   Site:
 12  channel unit, 3 channel(s) selected:  1 2 3
 Channel(s) triggered:  1 2 3
Comment:  WES spare
UserCodes:   0  0  0  0

Main battery: 13.60V, charging, minimum alarm voltage: 12.0V
   24 bit A/D with group delay: 0 msec
Temperature:  28.7 deg.C

Restart Source(s):  None Known.

System Error(s):  None Known.

Block File Transfer Buffer: Dynamic 256 - 2048 bytes

Altus Time Source: Keyboard.
Event Start Time:       3/22/2005 (81)  08:14:07.000
Event Trigger Time:     3/22/2005 (81)  08:14:10.600

Samples per second:  200
Duration:  15.000 seconds, 150 frames
Pre-event:  3 seconds.
Minimum runtime:  0 seconds.
Post event:  10 seconds.
Array Propagation Window:  0 seconds.
Storage: Primary  A:, Secondary  A:

Digital Field Station OFF.

Program versions:   sysBlk 0.00, bootBlk  1.09;        appBlk 2.89,  dspBlk
1.23

User input or GPS averaged:
Instrument latitude: 31.756130 Degrees North
Instrument longitude: 88.128403 Degrees East
Instrument elevation: 0 Meters relative sea level.

GPS latitude:  0.00 Degrees North
GPS longitude:  0.00 Degrees East
GPS altitude: 0 Meters relative sea level.

Ch                    1              2              3
  MaxPeak:       -0.0022835V     0.0210202V     -0.0162864V
   at seconds:         3.545          3.605          1.110
  MinPeak:       -0.0387162V     -0.0342494V    -0.0470537V
   at seconds:         3.640          3.550          1.140
  Mean:          -0.0209379V     -0.0056374V    -0.0303578V
  AcqOffset:      0.0000000V     0.0000000V      0.0000000V
```

```
Ch                    1               2               3
  Chan ID:            X-T,            Y-L,           Z-UP,
  Sensors:       EpiSensor (32)   EpiSensor (32)   EpiSensor (32)
                   s/n  9149        s/n  9074        s/n  9052
  MappedChannel:      1               2               3
  Inverted:           no              no              no
  Displace, N:       0000,           0000,           0000,
  Displace, E:       0000,           0000,           0000,
  Displace, U:       0000,           0000,           0000,
  Alt,Azi(deg):      0,      0       0,      0       0,      0

Ch                    1               2               3
  Gain:               1               1               1
  Fullscale         2.50V           2.50V           2.50V
  Sensitivity:      1.2490V/g       1.2510V/g       1.2500V/g
  Damping:          0.7000          0.7000          0.7000
  NatFreq:         212.00Hz        206.00Hz         212.00Hz
   EpiSensor only:
   CalCoil:         0.0610          0.0590          0.0590
   Sensor Gain:       1               1               1
   Range:             2g              2g              2g
 Sensed Sensitivity: 1.25V/g         1.25V/g         1.25V/g

Ch                         1               2               3
Trigger Threshold:       0.400%FS        0.400%FS        0.400%FS
Detrigger Threshold:     0.400%FS        0.400%FS        0.400%FS
Alarm Trig Threshold:    1.000%FS        1.000%FS        1.000%FS
               Votes:       1               1               1

External Trigger:  OFF,   Votes: 1
Keyboard Trigger Votes: 1
Stream:   Votes to trigger: 1,   Votes to detrigger: 1

GPS Free Field.
GPS turn On interval:  30 minutes(s).
GPS maximum On time:  30 minute(s)
All times as set manually, or 0.00 hour(s) from UTC if from GPS
Clock Source: Keyboard.
GPS Status byte decoded:
   GPS not present.
   GPS not locked.
   GPS power is ON.
GPS state of health byte [same as Acutime SOH byte]:
  Don't have GPS time yet.
GPS updated the RTC 0 times since last reset.
Drift at last two RTC updates to UTC: 0 & 0 msec.
Last GPS Update times were:
  1/1/1980 (1) 00:00:00 & 1/1/1980 (1) 00:00:00.
Last GPS TurnOn times were:
  3/22/2005 (81) 07:58:28 & 3/22/2005 (81) 06:06:11.
Last GPS Lock times were:
   1/1/1980 (1) 00:00:00 & 1/1/1980 (1) 00:00:00.
Count of times GPS failed to lock
    within gpsMaxTurnOnTime: 594
```

```
Modem strings [ NULL TERMINATED ] from event header...
 Initialization: AT&FE0&C1S0=1&W
 Dialing Prefix: ATDT
 Dialing Suffix:
 Hangup command: ATH0
 Callout message:
 Callout Acknowledge message:
Cellular Phone Parameters:
  Power control(CPPC) OFF, Duration 0 minutes.
  Warmup or timed recording length: 0 seconds
  Cell Trigger timed recordings are disabled.
    Duration: Power control ON duration(minutes) + warmup(seconds).
  Call-In Window Times or timed event start times:
   OFF    OFF    OFF    OFF    OFF
  CheckinTime(callout): not active
 Phone Numbers:
   1:     2:
Automatic answer ON.
 Wait for connection 45 seconds.
 Pause 10 seconds between calls.
 Extend pause between calls 0 minutes
 Call complete based on MODEM ACK setting (0).
 Max dial attempts: 10.

End Altus Etna Header S/N 3392, C:\SMIP\EARTHQ~1\ALEQ03~1\CF003.EVT


QLWIN calculated statistics for all data points in
C:\SMIP\EARTHQ~1\ALEQ03~1\CF003.EVT:

Ch                    1                 2                 3
 MaxPeak:         -0.0022835V        0.0210202V       -0.0162864V
 MinPeak:         -0.0387162V       -0.0342494V       -0.0470537V
 Peak-Peak         0.0364328V        0.0552696V        0.0307673V
 Mid-point        -0.0204998V       -0.0066146V       -0.0316700V
 Mean:            -0.0209438V       -0.0056386V       -0.0303583V
 BaseLine Correction ........
  Max-Mean:        0.0186603V        0.0266587V        0.0140719V
  Min-Mean:       -0.0177724V       -0.0286109V       -0.0166954V

End QLWIN calculated statistics, C:\SMIP\EARTHQ~1\ALEQ03~1\CF003.EVT
```